

Larsoft Electron Drift Simulation

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Voxels → Pixels

- Created sim::LArVoxelList output using Bill's code
 - Worked the first time
- New electron diffusion module
drfel::DriftElectrons
 - With lot's of handholding by Brian & Bill
 - DriftElectrons.cxx
 - Electron diffusion code
 - PlnPix.cxx
 - Plane pixel class

DriftElectrons Parameters

- Output folder name: PlnPix
- Random number generator seed
- Electron Drift Velocity
 - fDriftVel = 0.16 cm/ μ s
- Longitudinal Diffusion Coefficient
 - fLongDiff = 6.2E-6 cm² μ s⁻¹
- Transverse Diffusion Coefficient
 - fTranDiff = 16.4E-6 cm² μ s⁻¹
- Recombination Factor
 - fRecombFactr = 0.7
- Diffusion Cluster Size
 - fClusterSize = 600

Ref: DocDB #313

Ref: Craig Thorn DocDB #289

Ref: See Proposal

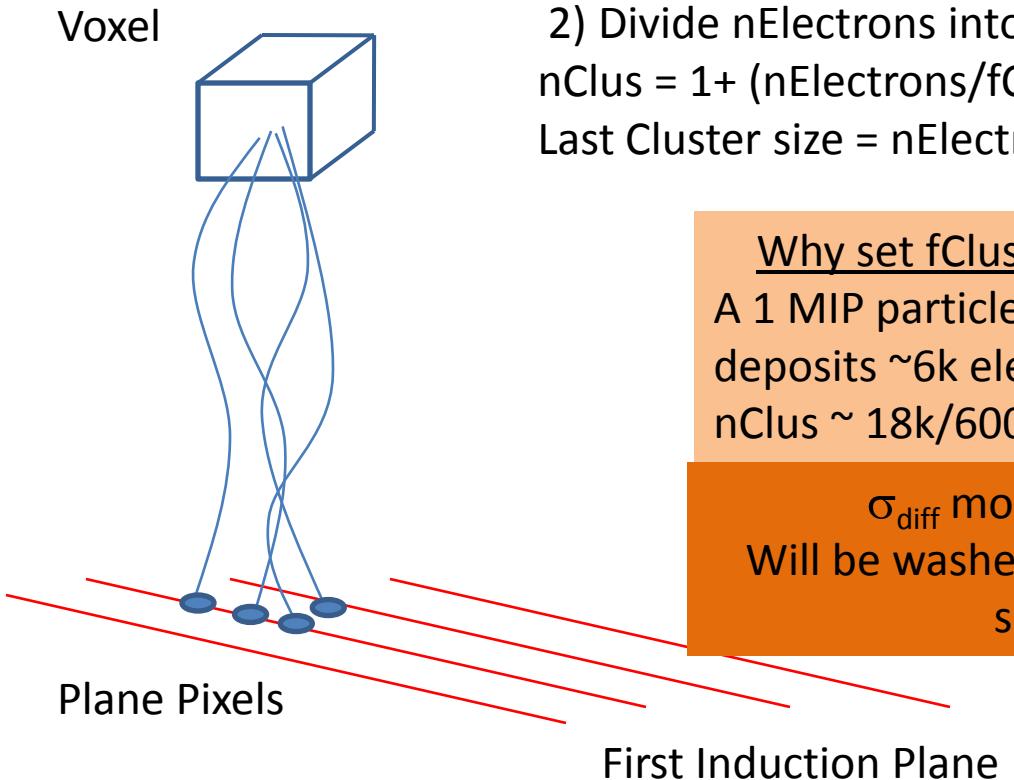
Ref: See next slide

Diffusion Cluster Size

Decouple voxel size effects and diffusion modeling

1) $n_{\text{Electrons}} = f_{\text{GeV2Elect}} * \text{Voxel Energy}$
 $(f_{\text{GeV2Elect}} = f_{\text{RecombFactr}} * 1E9 / 23.6 \text{ eV/ion pair})$

2) Divide $n_{\text{Electrons}}$ into
 $n_{\text{Clus}} = 1 + (n_{\text{Electrons}} / f_{\text{ClusterSize}})$ clusters
Last Cluster size = $n_{\text{Electrons}} - (n_{\text{Clus}} - 1) * f_{\text{ClusterSize}}$



Why set $f_{\text{ClusterSize}} = 600$ electrons?

A 1 MIP particle perp to a wire
deposits $\sim 6k$ electrons (1fC) /mm * 3 mm
 $n_{\text{Clus}} \sim 18k / 600 \sim 30$ clusters/wire

σ_{diff} modeling error $\sim 15\%$
Will be washed out by $1 \mu\text{s}$ electronics
shaping time

Algorithm

- Use TRandom3 – Cadillac random number generator
 - No simulation of electron lifetime
 - $X_{\text{Drift}} = X_{\text{IndPln}} - X_{\text{voxel}}$ Drift distance
 - Require $X_{\text{Drift}} > 0$
 - $T_{\text{Drift}} = X_{\text{Drift}} / f_{\text{DriftVel}}$ Drift time
 - $L_{\text{DiffSig}} = \text{Sqrt}(2 * f_{\text{LongDiff}} / T_{\text{Drift}})$ Diffusion σ (cm)
 - $T_{\text{DiffSig}} = \text{Sqrt}(2 * f_{\text{TranDiff}} / T_{\text{Drift}})$
 - $X_{\text{Diff}} = f_{\text{Random}} \rightarrow \text{Gaus}(0, L_{\text{DiffSig}})$ X diffusion
 - $T_{\text{Diff}} = T_{\text{Drift}} + X_{\text{Diff}} / f_{\text{DriftVel}}$ Diffusion corrected drift time
 - $Y_{\text{Diff}} = f_{\text{Random}} \rightarrow \text{Gaus}(Y_{\text{voxel}}, T_{\text{DiffSig}})$ Y,Z diffusion
 - $Z_{\text{Diff}} = f_{\text{Random}} \rightarrow \text{Gaus}(Z_{\text{voxel}}, T_{\text{DiffSig}})$
- Repeat nClus times*

Plane Pixels

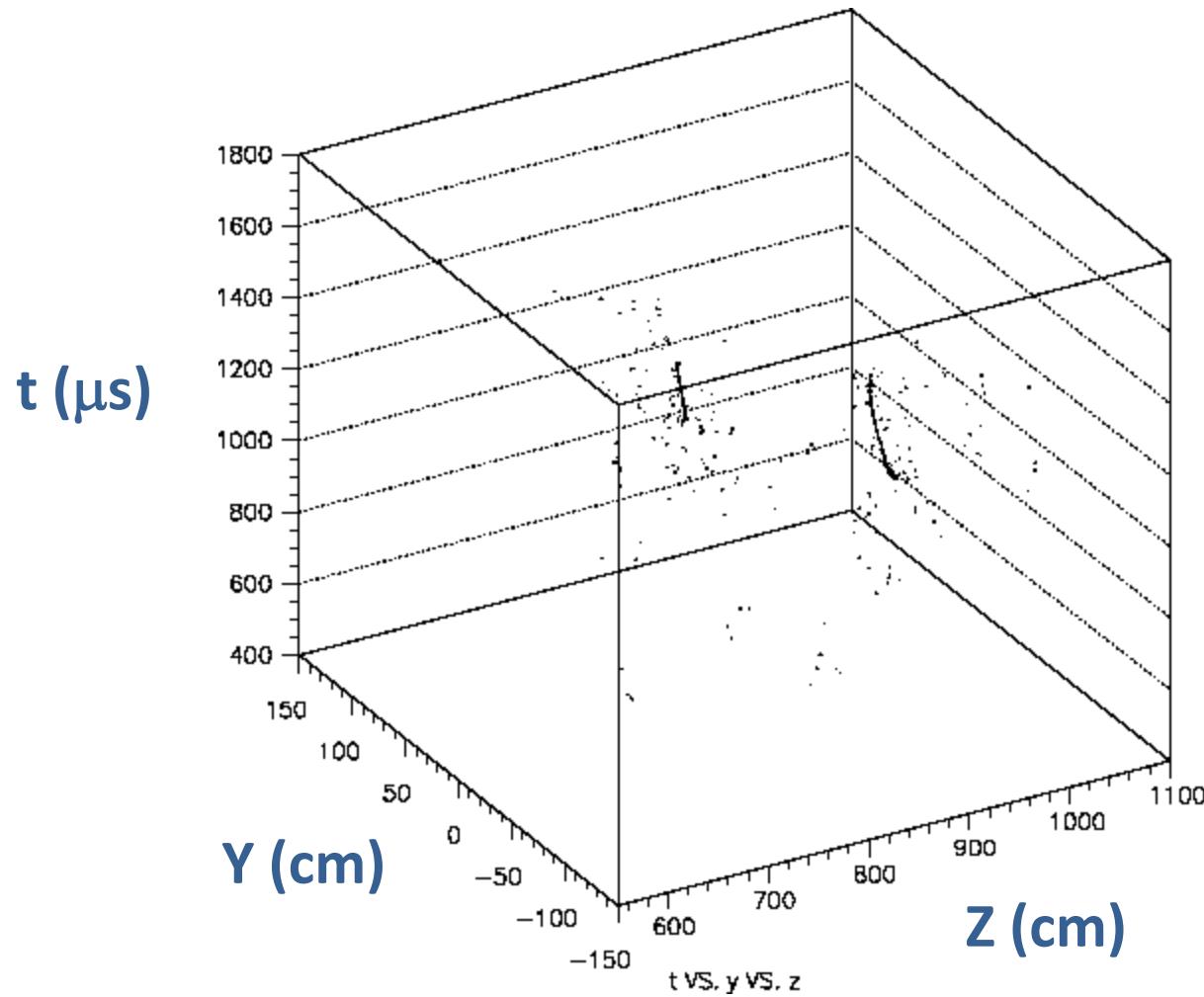
- PlnPix Class: Electron arrival information at the 1st induction plan
 - ArriveY, ArriveZ, ArriveT, nElectrons
 - Units are cm and μ s
- Vector of PlnPix stored in PlnPix folder under evt.DetSim
 - This vector should be deleted after signal simulation is completed

Validation

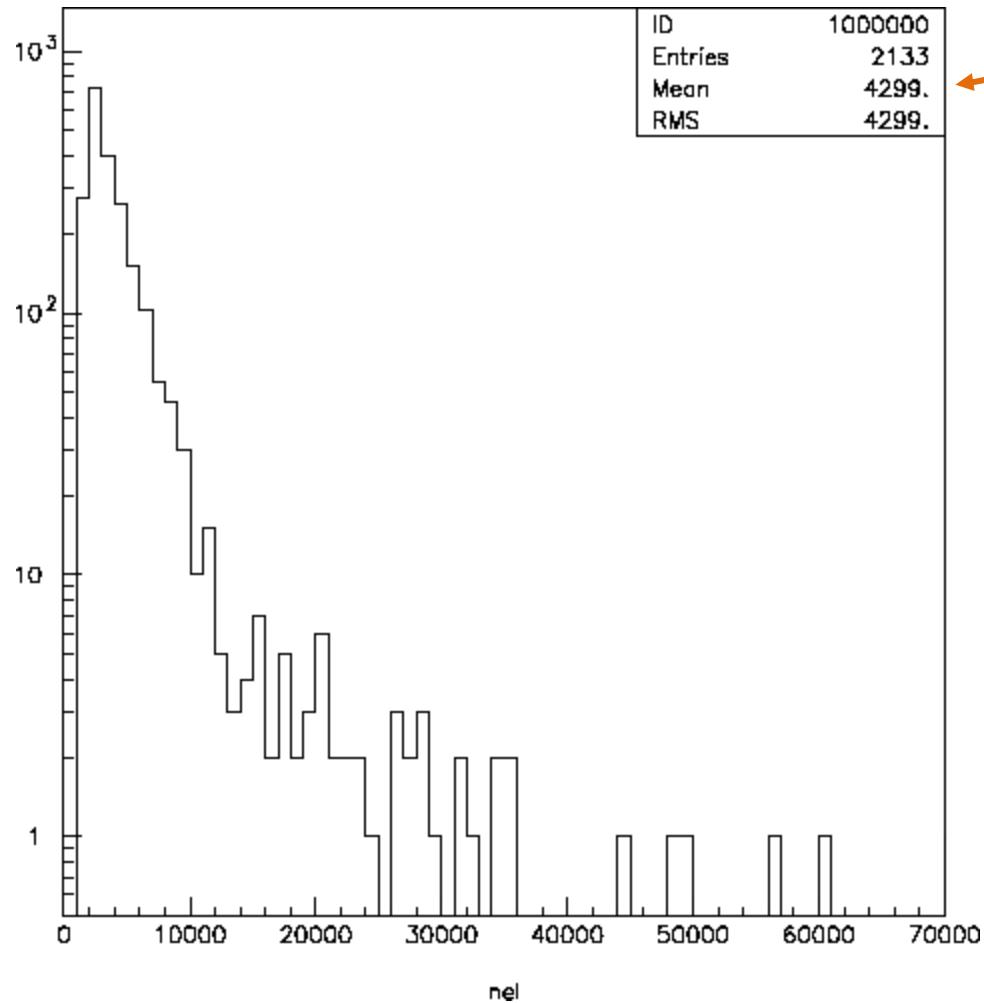
- Set voxel size = $100 \mu\text{m}^3$
- Set cluster size huge to get 1 pixel/voxel
- Run voxel code on 2 CCmu events → numu_vox.root
- Run drift electron code → numu_pix.root
- Run MCCheckOut, dump out pixel information & histogram

Y,Z,t from Pixels

2 Events



Pixel Energy → Electrons



4.3k Electrons/Voxel
~ 0.7 fC/Voxel

This is 10x higher
than one would
expect for a single
MIP event

A sample of 3 GeV muons
in the (0,0,1) direction
would be useful to check
code